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Assessment of vegetation cover change and dynamic in Sheikan, North Kordofan, Sudan

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ABSTRACT

This research was conducted in Sheikan locality, North Kordofan State during 2014 - 2015. It aimed to assess vegetation cover change by comparing changes in density and composition of trees, shrubs and herbaceous plants in the period 2014 and 2015 with that of 2007. The area was classified based on climatic zones into two sites North and South. In total, 10 and 25 plots (0.1 ha) were systematically placed in each site for assessment of trees and shrubs as well as herbaceous layer, respectively. Social survey was also carried out and 80 % of the peoples in the area were interviewed. Data scored was analyzed for ecological parameters (density and

relative density), analysis of variance was done using SAS software while social data was analyzed by Statistical Packages for Social Sciences (SPSS) where Duncan Multiple Range Test was used. Results identified 14 trees, 2 shrubs, and 27 herbaceous plants including grasses. Significant differences ($P \leq 0.05$) were found in density of trees between North and South where significant variations were limited to specific species in certain sites e.g. density of *Balanites aegyptiaca* was 20 trees per hectare in the north while it was 8 trees per hectare in the South. There was significant difference ($P \leq 0.05$) in existence and appearance of tree species between 2007 and 2014 where *Acacia seyal* var. *seyal* (Talih Ahmer) and *Capparis decidua* (Tundub) disappeared and *Bauhinia rufescens* (Kulkul) appeared in 2015. The results also revealed decrease in density of *Cenchrus biflorus* (Haskaneit Naim) and *Fimbristyls dichotoma* in 2015 compared to 2014. Compared to the last 11 years, unpalatable species appeared such as *Commicarpus africanus*. The status of the pasture is considered good. Agriculture expansion and overstocking affected plant vegetation cover. The pasture status direction deteriorated under improper management. Further studies were recommended to assess the effect of grazing on pastoral plants to determine direction of pasture status.

Keyword: Assessment, vegetation cover, North and South Shikan locality

1. INTRODUCTION

In Sudan rangelands occupy 50% of the country's area and produce about 80% of animal feed requirements. They extend in desert, semi-desert, low rainfall savannah, montane vegetation and riverine vegetation (Musnad, 1970 and Quideau, 2005). Natural grasses and herbs play a significant role in soil conservation, watershed protection, desertification control, carbon sequestration, maintaining biodiversity, providing medicines, and in the release of plant nutrient elements during the process of humification and mineralization of decomposed grass roots (Musnad, 1970 and Quideau, 2005). Livestock and/or its products are the primary source of income for over 60% of the North Kordofan population (El-Hag *et al*., 2011). Vegetation production in arid and semi-arid regions is closely related to the long-term average precipitation (Rutherford, 1980) and inter-annual rainfall variability (Le Houérou *et al*., 1988). However, literature on vegetation cover in savannah region and worldwide discussed the deterioration due to human pressure and climate change. Understanding the dynamics and causes of these changes is required for more efficient landscape management at both local and regional levels. Sudan is frequently subjected to drought (Ellis, 1992), which is the main limiting factor on biomass production; crop yields and loss in vegetation cover (Akhtar, 1997). UNSO (1997) estimated that overgrazing for 47% of the clearance of natural vegetation, whereas mechanized cropping and woodcutting, and urban demand for charcoal account for 22% and 19% respectively. According to Ibrahim (2009) and Omer *et al*., (2013) the degradation of vegetation in overstocked pastures took place both quantitatively and qualitatively. Useful species disappeared and replaced by unpalatable species, an example of that is *Calotropis procera* which spread widely on exhausted soils. Unpalatable species, such as *Senna alexandrina*, *Acanthospermum hispidum* and *Gueria senegalensis* occupied vast areas and replaced former palatable pasture grasses, such as *Cenchrus biflorus*, *Eragrostis spp*. and *Aristida spp*. This research aimed to identify the diversity of rangeland species, to explore reasons and dynamic of changes, to determine invasive plant species and to investigate the impact of environmental factors and human activities on the vegetation cover in period from 2005 to 2017 in Sheikan locality.

2. METHODS AND MATERIALS

Study area

Sheikan locality lies in the center of the Kordofan between latitudes 25' 12°, 45' 13° North and longitudes 35' 29°, 30' 30° east. It covers an area of about 8312 Km^2 (≈2 million acres), mostly useful for agriculture and grazing activities (Figure 1). Sheikan locality is located within the semi-desert zone where the average annual rainfall is between 250-450 mm^2/year during the rainy season (June to October). The last ten years showed considerable fluctuations in rainfall. The average temperature in Sheikan locality during 2005-2014 was 35.04 ^0C ranging from low average 34.5 ^0C during 2007 to high average of 35.6 ^0C during 2009 and 2010. The average relative humidity during 2005-2014 was 41.78% ranging between 37% during the year 2005 to 45% during the year 2012. There are two common types of wind in Sheikan locality namely the north and north-east wind with high velocity (10-20 node/second) during October to April of each year, while south and south-west humid wind is common during May to beginning of October (Metrological Station, North Kordofan, 2014). Acidic to alkaline sandy plains are dominant in northern parts of Sheikan locality and cover about 75% of the total area whereas, in the southern parts of the locality clay and Gardud soils cover about 5% and 20% respectively. The sandy soils share similar properties with the Qoz land soils. The sandy clay and sandy clay loam soil, locally known as "Gardud", have subsurface horizons of clay accumulation (LUWPA, 1994). Acacias are the dominant species in northern dry part

while species of broad leaves are scattering in the southern regions. The common species are *Acacia oerfota*, *Acacia mellifera*, *Acacia seyal* var. *seyal*. The herbal and grass vegetation is scattered in the area due to the low soil fertility and over grazing near nomad settlement areas (Makarives). The common species are *Pavonia patens*, *Aristida mutablis*, and *Acanthus polystachius* (Department of Agricultural Planning, 2014).

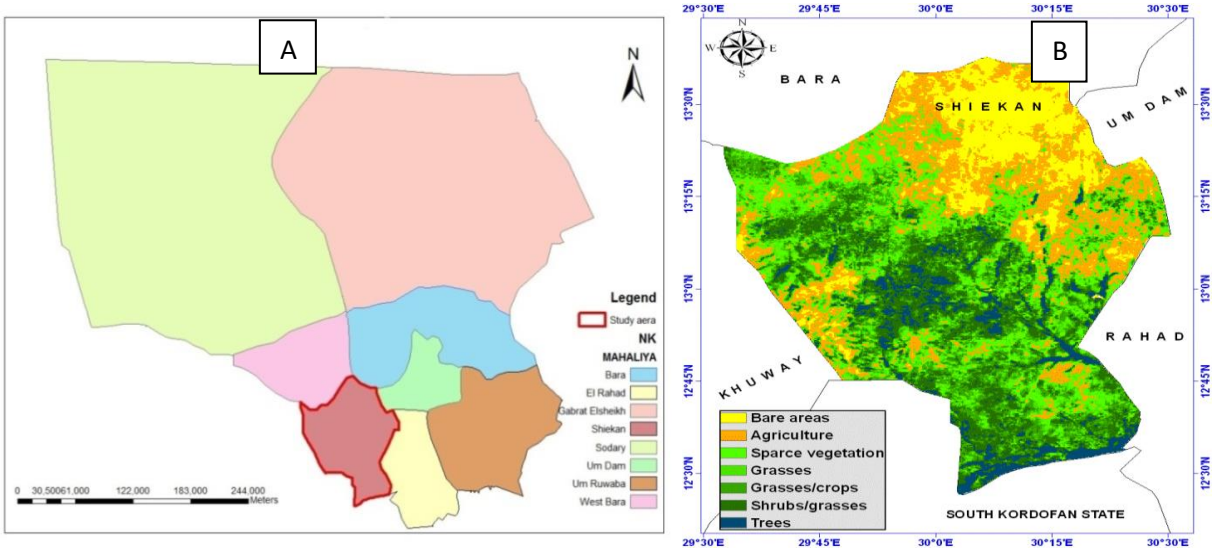

Figure 1 Map of Sheikan locality (A) and types of vegetation (B) in Sheikan locality (Source: Khatir, 2014)

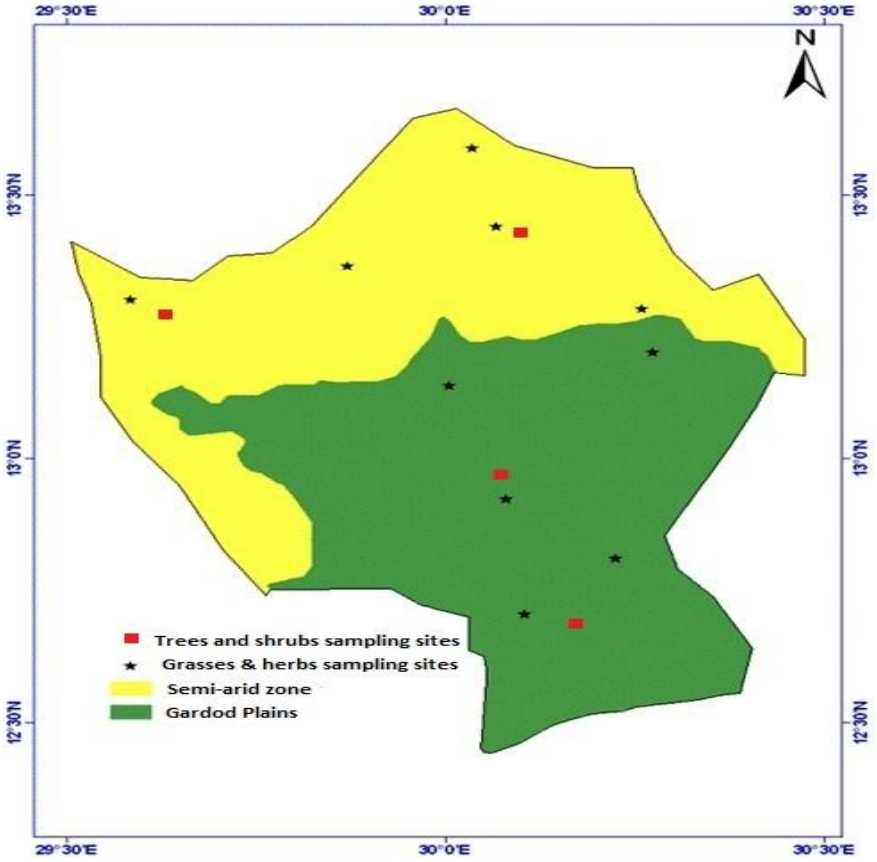

Figure 2 Distribution of sampling sites and sample plots in the study area

Data collection and analysis

The study area was divided according to the climatic zones into two main parts, north (semi-arid zone) and south (gardud plains) (Figure 2). Primary data were collected through field surveys which were conducted during rainy season of 2014 and 2015. In each

site 5 points for herbaceous species and 2 points for trees and shrubs were randomly selected and coordinated by GPS (Garmin Map60) and mapped by using ArcMap software. Then, in each point 5 sample plots of 0.1 ha were systematically located in space of 200 meter apart. The collected data in each sample included identification and count the number of trees, shrubs and herbaceous species, trees and shrubs diameter (cm) and height (m), soil type, fire, dead plants and growth habit and regeneration. Social data was collected through survey and interviewing 80 individuals of the local inhabitants for information about the current and past species, the invading species as well as the disappeared species were also collected. The scored data for the year 2014 and 2015 was arranged in Excel spread sheet and analyzed for ground Cover (Proportion of vital plants, litter, bare soil and rocks) and plant Composition (Plant cover %, density, relative density, frequency, relative frequency, and forage and shrubs productivity) compared to data scored in 2007. The density and frequency of tree species was calculated according to (Grieg and Smith, 1957; 1982) while forage production (g /m^2 or km/fed or Ton /fed) and vegetation cover (%) of total area (Plant +Litter + Bare soil + Rocks) were calculated based on Khatir (2012). Descriptive statistics, analysis of variance were run using SAS and SPSS software. Nomenclature was based on Darbyshire et al., (2015) and local name were extracted from local knowledge and taxonomic list were prepared by arranging families, genera and species in alphabetic order.

3. RESULTS AND DISCUSSION

Density and relative density of some selected trees and shrubs in Sheikan locality in 2014

There was significant difference between densities of the tree species in the north and the southern part of the locality Table 1. There are 34 *Acacia senegal* trees per ha (P ≥ 0.026) in the north. This density could be as a result of attention paid to this tree for its economic and environmental importance. It was found that *A. senegal* was the dominant tree species in the north due to the good site conditions. Other species such as *Balanites aegyptiaca*, *Boscia senegalensis*, *Indigofera suaveolens, Ziziphus spina -christi*, *Leptadenia pyrotechnica, Adansonia digitata* and *Acacia mellifera* showed 20, 14, 10, 6, 4, 0, and 0 trees/ha in the north respectively. However, their density was 8, 6, 2, 8, 0, 8, and 26 trees/ha in the south for the same species respectively. Some species were not found in the north such *Acacia mellifera* and *Adansonia digitata*, this may be referred to the problem of Baobab establishment in the sandy soil of the locality and the intensive grazing, *Acacia mellifera* was intensively cut for fuel and firewood. Some species are not found in the south such as *Leptadenia pyrotechnica* because it naturally grown in sandy soils (Table 1).These results agree with El Tahir *et al*. (2010) ; IIED and IES (1990). The results of (Table 1) also confirmed by the result of interviews carried where 75% of respondents confirmed that *Acacia mellifera* was the dominant tree in the southern part of the locality. However, there was no significant difference in the density of trees in the northern part.

Table 1 Density and relative density of some selected trees and shrubs in Sheikan locality in 2014

Species	Density/ha			Relative density		
	North part	South part	P ≥ F	North part	South part	P ≥ F
Acacia senegal	34.0	0.0	0.026	12.4	0.0	0.254
Balanites aegyptiaca	20.0	8.0	0.006	6.72	3.4	0.023
Acacia mellifera	0.0	26.0	≥ 0.0001	0.0	13	≥ 0.0001
Boscia senegalensis	14.0	6.0	0.062	4.92	2.8	0.138
Ziziphus spina- christi	6.0	8.0	0.044	1.98	3.2	0.042
Indigofera suaveolens	10.0	2.0	≥ 0.0001	3.3	1.0	0.0007
Adansonia digitata	0.0	8.0	0.052	0.0	3.4	0.086
Leptadenia pyrotechnica	4.0	0.0	0.083	1.44	0.0	0.083

Density of the trees in Sheikan locality in 2007 and 2014

Table 2 shows the density and frequency of trees and shrubs in Sheikan locality in the year 2007 and 2014 .The highest density was recorded for *Boscia senegalensis* which was 47 trees /ha, while , *Acacia oerfota* scored 37 trees/ ha. This result could be attributed to the well adaptation of these species to harsh climatic conditions that encountered the study area. These shrubs are also non desirable species to the grazing animals that is why they are in increase. The lowest density was observed for *Bauhinia rufescens* (2 trees/ha). A number of some species increased in 2014. These include which was *Acacia senegal* (34 trees/ha), *Ziziphus spina-christi* (14 trees/ha) and *Grewia tenax* (4 trees/ha) (Table 2). This good situation could be due to the attention and protection of these

species by local people. Some tree species appeared later such as *Indigofera suaveolens* and *Bauhinia rufescens*. In 2007 *Acacia seyal* var. *seyal* and *Capparis decidua* were present while the survey of 2014 revealed their disappearance. It could be said that, some attention was given to these species due to the increasing demand and intensive local uses (economic values) in addition to producing the charcoal production for commercial purposes particularly from *Acacia seyal* var. *seyal* (Table2).

Table 2 Density (tree/ha) of the trees in Sheikan locality in 2007 and 2014

Species	Years	
	2007	2014
Boscia senegalensis	46.7	20.0
Acacia oerfota	36.6	10.0
Acacia senegal	29.0	34.0
Acacia mellifera	19.05	26.0
Faidherbia albida	12.0	16.0
Adansonia digitata	10.0	8.0
Calotropis procera	9.8	12.0
Acacia seyal var. *seyal*	4.15	0.0
Acacia nilotica	4.0	6.0
Leptadenia pyrotechnica	3.43	4.0
Grewia tennax	2.0	4.0
Capparis decidua	1.49	0.0
Ziziphus spina-christi	1.13	14.0
Balanites aegyptiaca	1.0	28.0
Acacia tortilis subsp. *tortilis*	1.0	10.0
Guiera senegalensis	1.0	2.0
Indigofera suaveolens	0.0	12.0
Bauhinia rufescens	0.0	2.0

Density of herbaceous layer (Under storey) in 2014 and 2015

Regarding the appearance and disappearance of the herbs, the increase and decrease in the number species, the results were shown in table 3. Some species such as *Schoenefeldia gracilis*, *Abutilon angulatum* were completely absent in 2014 but appeared in 2015 in the northern part of the locality. *Zorina diphylla* was also completely absent in 2014 in both north and south of the locality but appeared in 2015 in the southern part only. The reason of appearance and disappearance of these grasses might be attributed to livestock mobility which helps in seed dispersal and enhanced the diversity. Occurrence of *Abutilon angulatum* also indicates the degradation of the area. On the other hand there was regular rehabilitation and seed programme by administration of the range particularly for *Dactyloctenium aegyptium* and *Zorina diphylla*. Some species decreased in 2015; *Fimbristyls dichotoma* from 23 to 5 plant /m^2, *Eragrostis tremula* from 22 to 8,*Cenchrus biflorus* from 18 to 14 plant /m^2 and *Acanthus polystachius* from 3 to 1 plant / m^2. This decrease could be due to the intensive grazing in the area. However, the number of *Aristida mutablis* increased in 2015 from 7 to 12 plant / m^2. It is worth mentioning that the increase of the rainfall might be the driving force for enhancing the increase number of the grass.

Table 3 The density (Plant / m^2 and Plant/ha) of herbs

Species	Year	Density (Plant/m^2)			Density (Plant/ha)		
		N	S	P ≥ F	N	S	P ≥ F
Cenchrus biflorus	2014	18.08 A	0.0 B	≥ 0.0001	1808 A	0.0 B	≥ 0.0001
	2015	14.84 A	0.56 B	≥ 0.0001	1482 A	5600 B	≥ 0.0001
Schoenefeldia gracilis	2014	0.0 B	7.96 A	0.0005	0.0 B	796 A	0.0005
	2015	3.56 A	0.28 B	0.045	356 A	2800 B	0.0005
Eragrostis tremula	2014	22.56 A	2.0 B	≥ 0.0001	2256 A	2000 B	≥ 0.0001
	2015	8.36 A	6.44 A	0.652	0.776 B	1.056 A	0.658

Acanthus polystachius	2014	3.84 A	0.04 A	0.055	384 A	400 A	0.0551
	2015	1.0 A	0.0 A	0.1475	8400 A	0.0 A	0.1475
Fimbristyls dichotoma	2014	23.2 A	0.0 B	≥ 0.0001	232 A	0.0 B	≥ 0.0001
	2015	5.32 A	0.0 B	0.0006	532 A	0.0 B	0.0006
Abutilon angulatum	2014	0.0 A	5.56 A	0.057	0.0 A	556 A	0.057
	2015	0.36 A	5.8 A	0.009	3600 A	5800 A	0.009
Aristida mutablis	2014	7.72 A	4.74 A	0.514	772 A	476 A	0.514
	2015	12.24 A	2.04 B	≥ 0.0001	1224 A	20400 A	≥ 0.0001
Dactyloctenium aegyptium	2014	0.0 A	0.76 A	0.105	0.0 A	7600 A	0.105
	2015	0.0 B	1.96 A	0.014	196 A	0.0 B	0.014
Zorina diphylla	2014	0.0 A	0.0 A	0	0.0 A	0.0 A	0
	2015	0.0 B	1.00 A	0.034	0.0 B	1640 A	0.0327

Indicators of pasture status in the period from 2005 to 2015

Results of indicators of pasture status in the period from 2005 to 2015 are shown in Table 4. There was an increase in percentage of pastoral plants and cover which were 69% and 65% in 2014 respectively. The lowest percentage of pastoral plants was 30% in 2007. The highest percentage of the pastoral plants might refer to the rehabilitation and reseeding process of the pastoral plants carried by administration range and pasture. This could be due to the intensive grazing in the area and consequently resulted in increasing the percentage of bare soil to reach 36% and rock to 6 %.The highest percentage of the litter was 34% in 2010 while the lowest percentage of the litter was 10% in 2015. This result could be also attributed to intensive grazing in 2010, while in 2015 all pastoralists migrated to the southern parts of the locality as a result of the rainfall fluctuation in 2015. The high productivity of the forage was found in 2014 where it weighted 59 g/m^2, while the lowest productivity was in 2011 which was 12 g/m^2. It was clear that the rainfall rate was high in 2014 (385 mm/year) and low in 2011 (245 mm/year).Generally the plant cover was about 65% and the average biomass production (weight) was 59 g/m^2 in 2014. Accordingly, the range condition is classified as "Good".

Table 4 The pasture status (%) and biomass (g/m^2)in Sheikan locality (from 2005 to 2015)

Years	Plant	Litter	B.S	Rocks	Cover	Biomass
2005	52.2	11.1	36.0	0.7	63.0	39.6
2006	43.5	28.6	27.9	0.0	59.0	45.8
2007	30.0	28.1	35.6	6.3	37.3	40.3
2008	51.0	25.4	23.6	0.0	34.2	40.1
2009	56.1	27.5	16.4	0.0	23.8	18.1
2010	57.0	33.9	9.1	0.0	64.2	14.5
2011	54.4	14.4	31.2	0.0	21.8	12.3
2012	0.0	0.0	0.0	0.0	0.0	0.0
2013	68.0	8.0	24.0	0.0	32.0	34.0
2014	69.1	11.9	18.3	0.7	65.0	58.8
2015	68.6	10.1	20.8	1.8	34.0	35.4

* Note: In 2012 the survey was done through remote sensing unit where they ignored the details of pastoral plants. B.S: Bare soil

Density of palatable herbaceous species (2005 – 2015) in Sheikan, North Kordofan

The average density of the desired plants during the last eleven years (2005-2015) shown in Figure 3. *Aristida mutablis* recorded the highest density of 12 plants/m^2 followed by *Eragrostis tremula* 10 plants/m^2 and *Cenchrus biflorus* 8 plants/m^2. This result could be attributed to the adaptation of these species to harsh climatic conditions that encountered. These shrubs are also non desirable species that is why they are in increase. The species are also less palatable to the animals. It was noted that relative densities and

frequencies of these species are increasing. The lowest average density was recorded for *Bergia suffruticosa* is which was approximately 1 plants/m^2. The reason refers to the disappearance of palatable species.

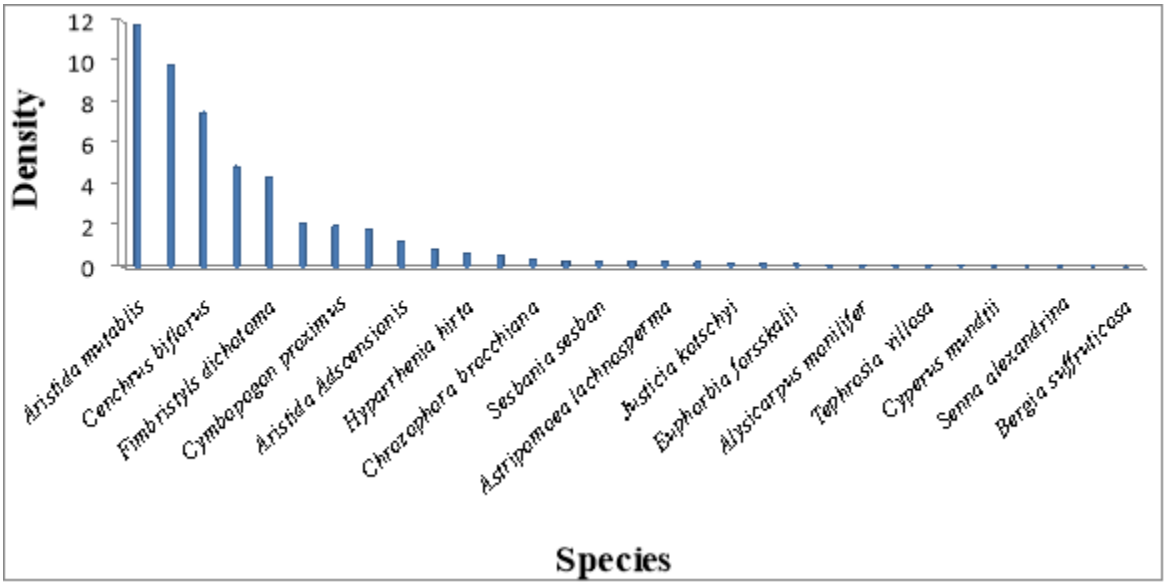

Figure 3 Average density (plant/m^2) of palatable herbaceous species in Sheikan, North Kordofan in (2005 - 2015)

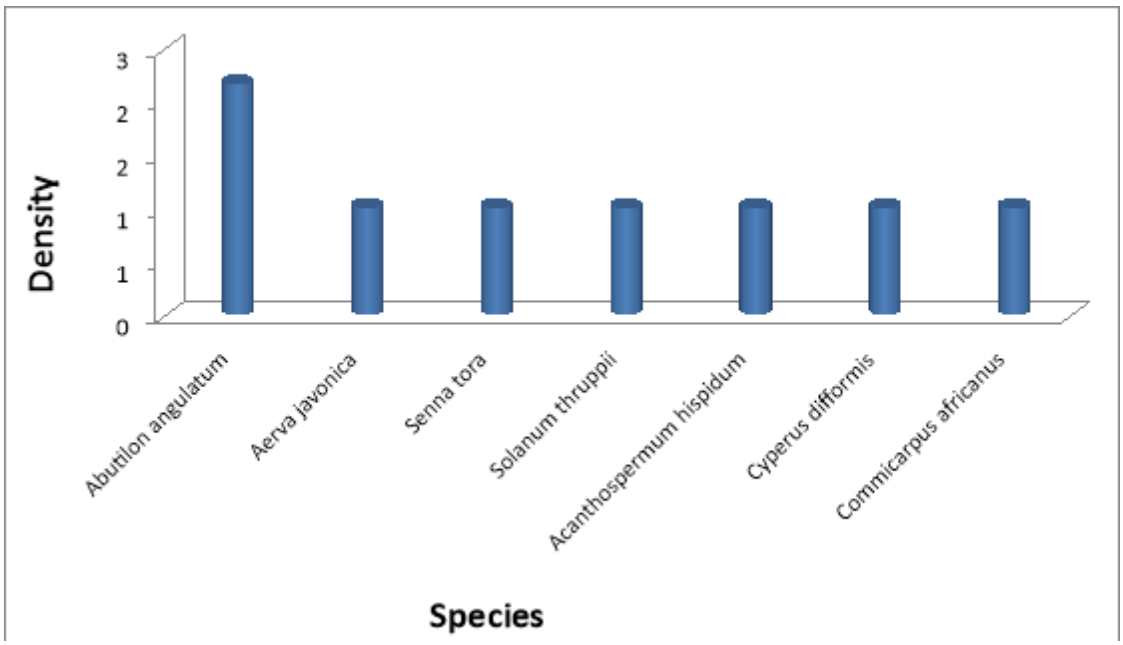

Figure 4 Average density (plant/m^2) of unpalatable herbaceous species in Sheikan locality in (2005-2015).

Density of unpalatable herbaceous species (2005-2015) in Sheikan locality, North Kordofan State

The highest average density of unpalatable species was attained by *Abutilon angulatum* which was 2 plants/ m^2 followed by *Aerva javonica* 1 plants /m^2. The lowest density was recorded by *Commicarpus africanus* which was 1 plants/m^2 (Figure 4). This could be attributed to agricultural expansion and grazing pressure around water sources in southern parts of the locality. It is worth mentioning that, the shepherds access the area with livestock that exceeded the carrying capacity of the pasture (table 5 & 6).

Table 5 Checklist of trees and shrub species in Sheikan locality, North Kordofan state

Family	Botanic Name	Local Name
Apocynaceae	*Calotropis procera*	Oshar
	Leptadenia pyrotechnica	Mareikh
Bombaceae	*Adansonia digitata*	Tabaldi
Capparaceae	*Boscia senegalensis*	Korsan
	Capparis decidua	Tondub
Combreaceae	*Guiera senegalensis*	Ghbeish
Leguminosae	*Acacia mellifera*	Kiter
	Acacia nilotica	Sunt
	Acacia oerfota	Lawot
	Acacia senegal	Hashab
	Acacia seyal var. *seyal*	Talih
	Acacia tortilis subsp. *Tortilis*	Seyal
	Bauhinia rufescens	Kulkul
	Faidherbia albida	Haraz
	Indigofera suaveolens	Singed
Malvaceae	*Grewia tennax*	Ghodeim
Rhamnaceae	*Ziziphus spina-christi*	Sider
Zygophyllaceae	*Balanites aegyptiaca*	Heglig

Table 6 Checklist of herbaceous plants in Sheikan locality, North Kordofan Sate

Family	Botanic Name	Local Name
Euphorbiaceae	*Chrozophora brocchiana*	Argasy
Poaceae	*Dactyloctenium aegyptium*	Abo asabia
Poaceae	*Echinochloa colona*	Defra
Fabaceae	*Zorina diphylla*	Shelini
Poaceae	*Cenchrus ciliaris*	Hskanitnaeem
Fabaceae	*Alysicarpus monilifer*	Freisha
Convolvulaceae	*Ipomoea coptica*	Hntoot
Poaceae	*Aristida adscensionis*	Homra
Rubiaceae	*Oldenlandia senegalensis*	Garagub
Malvaceae	*Pavonia patens*	Tgtaga
Pedaliaceae	*Sesamum alatum*	Semsemgomal
Poaceae	*Eragrostis tremula*	Bannu
Poaceae	*Cenchrus biflorus*	Hskanitkhishen
Cyperaceae	*Fimbristyls dichotoma*	Um Fsesiat
Poaceae	*Aristida mutablis*	Ghaw
Acanthaceae	*Acanthus polystachius*	Tamr Far
Boaceae	*Schoenefeldia gracilis*	Dnab Naga
Convolvulaceae	*Astripomoealachnosperma*	Um ghilela
Acanthaceae	*Justicia ladanoides*	Nanaakhalawy
Fabaceae	*Tephrosia villosa*	Hreisha
Poaceae	*Cymbopogon proximus*	Mhareeb
Euphorbiaceae	*Euphorbia forsskalii*	Um lbeina
Malvaceae	*Corchorus olitorius*	Mlokheiakhala
Poaceae	*Chloris gayana*	Rodas
Cyperaceae	*Cyperus mundtii*	Um Touk
Elatinaceae	*Bergia suffruticosa*	Rimta

Poaceae	*Hyparrhenia hirta*	Um Semema
Asteraceae	*Geigeria alata*	Ghdgad
Zygophylaceae	*Tribulus terrestris*	Dreisa
Fabaceae	*Sesbania sesban*	Soreib
Fabaceae	*Senna alexandrina*	Snamka
Malvaceae	*Abutilon angulatum*	Niada
Fabaceae	*Senna tora*	Kawal
Solanaceae	*Solanum coagulans*	Gbeain
Amaranthaceae	*Aerva javonica*	RasAlshaieb
Cyperaceae	*Cyperus difformis*	Seada
Acanthaceae	*Acanthospermum hispidum*	Horabhawsa
Nyctaginaceae	*Commicarpus africanus*	Abo Iseag

4. CONCLUSIONS

Some shrubs appeared in high densities e.g. *Indigofera suaveolens* and *Bauhinia rufescens* in the southern part of the locality. The rehabilitation and reseeding programs resulted in great advantages for cultivation of some species such as *Acacia senegal, Ziziphus spina- christi*and *Grewia tennax* especially around farms. Other shrubs increased in density; e.g. *Calotropis procera, Leptadenia pyrotechnica* and *Guiera senegalensis,* while some interviewees stated that tree cutting is considered the main factor that affect the density. The dominant species were *Aristida mutablis, Eragrostis tremula* and *Cenchrus biflorus.* The increasing of rainfall, low competition of species, and seasonal fire especially in the northern part of the locality were noticeable. Some species disappeared later such as, *Oldenlandia senegalensis, Pavonia patens, Alysicerpus monilifer*, *Cenchrus ciliaris* and *Aristida adscensionis*. There was change in species composition and structure, which was noticed for *Dactyloctenium aegyptium*, *Zorina diphylla, Echinochloa colona, Chrozophora brocchiana,* and *Ipomoea coptica*. Overgrazing in southern part concentrated in El makarives areas. Agricultural expansion allowed high density of invading species as *Commicarpus africanus* and *Abutilon angulatum*. The status of the pasture is considered good. The main influential factors caused change were expansion in agriculture, increasing pressure on pasture and increase of population and livestock as a result of displacement of pastoralist and nomadic. The direction of pasture status could be deteriorated in case of increase and continuity of the influential factors.

Recommendations

Policies and strategic plans should be activated for improving and developing the utilization of grazing system in the natural pastures. Improving range quantitatively and qualitatively through ideal range seeding with consider of adaptability of the seeds, Seed tests should be done in case of adequate moisture in the soil. Early survey is annually needed.

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Conflict of Interest: The authors declare that there are no conflicts of interests.

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